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Cognitive and Institutional Perspectives of Eco-Efficiency

A New Research Landscape Towards Factor Four (or more)

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Abstract

The paper sketches out a theoretical framework for analysing the interplay between eco-efficiency, cognition and institutions. It derives from analytical shortfalls of the prevailing literature, which features strongly engineering and business economics, by using insights from New Institutional Economics, from Cognitive Sciences and, partly, from Evolutionary Economics. It emphasises the role cognition and institutions play in the adoption of "green" technologies by firms. A cognitive perspective derives from recent research on simple heuristics and context-based rationality; it is proposed that those recent findings can serve to analyse decision-making of individual actors or firms and, thus, should complement economic analysis. A second proposition is that eco-efficiency and normative rules such as a Factor Four strongly rely upon institutions, i.e. the ability of institutions to evolve over time and the development of those institutions that are most appropriate to enhance technological change. In this regard, business institutions and competition are crucial, but regulatory needs remain in order to safeguard continuity of knowledge creation. The framework allows for an analysis why overall adoption of eco-efficiency still can be considered relatively slow and why some markets and firms are far ahead. As a brief case study the article reflects upon German waste law's ability to enhance eco-efficiency.

Keywords: Technical Change, Institutional Change, Cognition, Knowledge Creation, Environmental Management, Factor Four

JEL-Categories: D8, L1, O3, Q2

1. Introduction

Improvements in environmental quality will only occur if technological options become available and are implemented. In this context, four different types of environmental technologies can be distinguished:

- *End-of-pipe technologies* such as scrubber technologies for SO_2, NO_x and other emissions which are added to a production chain;
- *Integrated technologies* which allow for the recycling of materials within an existing production chain;
- *Eco-efficiency technologies* that allow for a reduction of physical production inputs (materials, energy, water) while maintaining economic performance;
- *New system designs* which completely restructure existing production chains.

Among these technology choices, eco-efficiency technologies, new system designs and related services are of special importance because of their huge application potential as well as their low costs (Weizsäcker et al., 1997; Lovins et al., 1999). Though research on the costs and benefits of these options at the level of individual firms continues to expand and can be expected to grow further within the next years, the available research analysing the cognitive and institutional dimensions of these options is still relatively poor. Kemp (1997), van Dijken et al. (1999) and Wubben (2001) have conducted some recent works on these items. In a broader vein, Söderbaum (1999) and Bizer (1999) reflect upon an institutional foundation of ecological economics.

It is our main thesis that eco-efficiency and new systems design strongly rely upon cognition and institutions,[1] i.e. the creativity of the human mind as well as the ability of institutions to evolve over time and stimulate technological change. This paper sheds light on what kind of cognitive and institutional mechanisms enhance a sustainable technology development. In this context, drawbacks of eco-efficiency such as a possible “abandonment of nature” (Hukkinen, 2001) or the well-known “rebound-effect” lead economics to query cognition and institutions too, and not to doubt the overall usefulness of eco-efficiency. Deriving from that thesis, recent findings of economics outside the ecological branch provide useful insights into the interplay between cognition and institutions. Any new conception of humans as claimed by Siebenhüner (2000), if necessary at all, is well advised to begin with a review of recent findings in cognitive science (Ostrom, 1998). Two

1 For the purpose of our paper, an institution is understood as a system of norms with respect to a particular set of activities. It consists of informal constraints, formal rules and the enforcement characteristics of both. See also: North (e.g. 1998).

propositions can be formulated: Firstly, acknowledging a cognitive perspective leads to permanent search efforts for innovation at the level of individual firms that are slightly above an “optimal” level of routine and exploitation of existing knowledge. Secondly, business institutions are able to conquer win-win markets, thereby internalising negative externalities, if they are guided by normative decision rules and by a flexible regulatory framework that sets incentives for knowledge creation.

To prove both propositions, the following paper will sketch out a theoretical framework based upon New Institutional Economics (NIE) and, partly, cognitive science and Evolutionary Economics. These branches intensively discuss some new assumptions about the constraints individuals face, capabilities they might gain and the processes by which their decisions are co-ordinated. In connecting their findings to the realm of ecological economics, the paper will demonstrate how and in which areas these assumptions prove to be useful. The paper is divided into five sections. The following chapter 2 examines literature on technological change towards eco-efficiency and some analytical drawbacks. Chapter 3 introduces recent findings from cognitive science and underlines their role in the adoption of “green” technologies by firms. Chapter 4 discusses institutional change and its ability to stimulate eco-efficiency. In chapter 5, the interplay between cognition and institutions is analysed with a focus on knowledge creation by both co-operation and competition. Chapter 6 applies insights derived from theory to a case study on German waste law and its ability to facilitate eco-efficiency. The final chapter arrives at conclusions for future research.

2. On the economics of technological change

The major role of firms and competition in driving technological change is well known in economics. Rosenberg (1994) and several others provide empirical evidence of these mechanisms. Recent evolutionary theories offer additional insights (Nelson, 1995). The literature on innovation and the environment retains this focus on the diffusion of discrete techniques, emphasising the importance of price signals (Jaffe et al., 2000). A striking observation is being made on the path-dependency of technological change. Describing, inter alia, the typewriter keyboard QWERTY, David (1985), Arthur (1989), and Foray (1997) demonstrate that investment decisions are not strictly flexible or perfectly malleable to market conditions but instead depend on certain paths or trajectories.

It could now be argued that path-dependency lead to an inefficient selection of technologies by market forces caused by imperfect knowledge and historical accidents. Path-dependencies would thus hinder firms from entering the new markets of eco-efficiency. But such a belief would be misleading. On the technical level, the necessity of carefully developing, testing and improving new technologies is obvious. Rosenberg (1994, p. 13) points to the fact that almost three-quarters of R&D costs are related to technical fine-tuning before a new invention starts to be produced. Synergistic effects with existing production processes and infrastructures also have to be taken into account. New products have to fit into existing structures; otherwise the overall switching costs become incommensurably high. These technical factors provide some convincing rational explanations in favour of path-dependencies. Using existing technologies allows for economies of scale (at a given demand), resulting from sinking production costs and increasing learning curves. New technologies and, furthermore, any shift towards a new system bears a high risk of sunk costs, as information about their development and their market demand is – by definition – largely unknown. According to Schlicht (1998, p. 67) path-dependency appears to be close to rational behaviour! It can be assumed that huge producers or emerging economies would have incentives to invest in superior technologies for single products, even if path-dependencies have to be considered.

While intuitively appealing, such an approach of viewing path-dependencies as part of overall market efficiency does not seem to capture the whole story. If it comes to technological regimes as composed of technical artefacts, organised on co-evolving market and regulatory frameworks, path-dependencies become more severe. Walker (2000) stresses with a view to large technology systems such as energy supply infrastructure the importance of embedded institutional, political

and economic commitments that lead to an "entrapment", i.e. risks of inertia and irreversibility. This would mean that a change in technological regimes requires additional and strong efforts by policies in order to unlock persistent trajectories. Berkhout (2002: 3) gives a brief overview on this debate in relation to the environment.

Would these observations reduce the scope of government to the management of change in technological regimes? At first glance, the distinction between "efficient" path-dependencies on markets for usual private goods and "inefficient" path dependencies in technological regimes seems to suggest such a policy conclusion. With regard to eco-efficiency, this would lead to no further regulatory needs because markets would almost automatically discover opportunities of low hanging fruits. But before arriving at such a conclusion one should ask whether the distinction made applies to markets of eco-efficiency. Can eco-efficiency technologies be treated as usual private goods? At first sight, eco-efficiency reduces costs and leads to profitable innovations like any other technological improvement. Companies will indeed try to explore these fascinating opportunities. On the other hand, this is like the notion of no big bills left on the sidewalk because somebody else must have picked them up already. Even researchers like Porter and v. d. Linde (2000) who emphasise business opportunities of eco-efficiency underline information deficits and uncertainties due to unknown market and regulatory trends. Our question is whether these barriers are stronger than those usually claimed by New Institutional Economics because of cognitive and institutional constraints that are unique to environmental technologies. If yes, technological change won't lead to growing efficiency without additional efforts specifically addressing knowledge creation in both arenas of businesses and policies. In this case, the relationship between technological change and the environment would look slightly more complex than often proposed in debates about environmental management. Furthermore, regulatory needs would arise that seem to fall between the usual dichotomies of economic incentives and command-and-control approaches. Given this hypothesis, a deeper analysis of cognitive and institutional factors in eco-efficiency becomes necessary.

3. Cognitive Perspectives of Eco-Efficiency

Economic theory usually assumes perfect rationality based upon perfect information when individuals make their choices. These assumptions are far stretched. As a potential alternative, the "bounded rationality" program based upon parts of cognitive science as developed by Simon (1957, 1978), Kahneman and Tversky (1996) has gained attention; Rabin (1998) provides an overview on the adaptation of psychology within economics. Accordingly, human beings are condemned to sub-optimal economic performance caused by cognitive constraints.

Research on eco-efficiency seems to be misplaced in both programs. Whereas the economic standard model usually falls short for dealing with ecological complexities and related information deficits, any bounded rationality perspective emphasising biased decision-making can hardly deal with standard questions about profits, incentives and competition. If firms can make a profit with eco-efficiency (as it is proved to be the case, see e.g. Porter and v.d. Linde 2000), why should research bother with rationality? Cognitive perspectives, however, matter

- Regarding the development and inducement of any technology since individuals' and firms' attention and the direction of searching for new information are limited;
- Regarding the analysis of market trends and selection processes since information-processing capacities of individuals and firms are limited and shaped by cognitive constraints;
- Regarding adaptation since the development of strategies depends upon cognitive factors that guide the search for solutions and link best-practice examples of competitors with firms' capabilities.

These dimensions are aggravated by the common goods[2] dimension of environmental technologies. This is especially important when policies address global public goods such as the earth's atmosphere and expect businesses to act in a preventive way. Firms suspect preventive measures of being costly because they contribute to a global public good, and free-riding activities of competitors are expected. Therefore, firms tend to act as second-movers and wait for actions taken by others. In addition, a reduction of cognitive dissonance by dispelling gloomy

2 Common goods can be defined as those goods that are not private; e.g. public goods, common-pool resources, club goods, and network goods. The term has been coined, inter alia, within the research scope of the Max-Planck Project Group on the Law of Common Goods in Bonn, Germany.

information about the likelihood of any natural disaster is a likely strategy. In such a perception, even the low hanging fruits of eco-efficiency are unlikely to be assessed. Furthermore, even if they are accounted to be beneficial at the level of individual firms, at least a residual quantity of commonly shared or even future benefits remains (*positive externalities*). How should firms calculate these benefits or ask for any share of the economic rent as long as they are faced with knowledge and regulatory uncertainties? Wouldn't they expect third parties to profit from those positive externalities and postpone any investment decision?

It thus becomes evident that mechanisms of cognition filters information on eco-efficiency in two regards: environmental management is perceived as a contribution to a public good and some benefits are perceived as future benefits that cannot be part of current revenues. Both points are unique to environmental technologies; they are stronger than the usual literature on information deficits claims.[3] Seen from this angle, the dissemination of information about the short-term gains of eco-efficiency and new systems design becomes as critically important as the mechanisms of knowledge creation at the level of individual firms. Prices won't do it alone.

What insights can be drawn from cognitive science in this regard? Surprisingly, recent cognitive research provides evidence of good performance while little information is processed. Featuring on how individuals deal with uncertainties and how they develop rules to stop their search for information, reference is being made to *simple heuristics* as rules-of-thumb, which make people smart by enabling them to quickly find proper solutions (Gigerenzer et al., 1999; Chase et al., 1998). Decision heuristics may include a "Take The Best" approach, comparing objectives of the most valid clue and ignoring the rest, or a "Recognition" approach assuming that well-known clues will infer the target variable. Ortmann and Gigerenzer (2000, p. 136) underline the methodological role of content specificity in reasoning. A case in point is the surgeon at an emergency ward who has to decide immediately about a casualty. Though sometimes mistakes are made, the success rate is apparently high. People do not deviate that far from rationality as parts of the bounded rationality program suggest.

Those simple heuristics can perform as well as any rational choice though they require less information and less time. Heuristics rather follow an ecological rationality, i.e. they are adapted to certain circumstances at certain places. Rationality thus becomes *context-based*. No single heuristic will lead to good decisions independent of the social and physical environment. Context-based rationality necessarily implies specificity and refers to both social and individual

3 Standard information economics assumes an optimal stop taking into account the costs of information search and the potential benefits of the new information. Such a stopping rule, however, can hardly apply to situations with huge uncertainties and ongoing knowledge creation.

cognitive constraints. Heuristics develop over a cascade of decisions, carried on and calibrated by experience among individuals. Choosing among appropriate rules, interpreting them and applying them to certain problem-solving processes can be regarded as permanent cognitive creation. It is an ongoing, normal process. In this analytical context, the economic notion of "shared mental models" as proposed by Denzau and North (1994) fits almost perfectly. If research takes the assumption of context-based rationality into account for experimental design, studies reveal that many people behave relatively well at reasoning about social contracts (Ortmann and Gigerenzer, 2000, p. 139). They intuitively assess various benefits resulting from different contracts, thus demonstrating social intelligence. It thus appears that simple heuristics and context-based rationality are important elements for a cognitive perspective of eco-efficiency, perhaps even for a wider context. Economics may keep some principles of methodological individualism like assumptions of self-interested, advantage-seeking behaviour, while integrating cognitive perspectives. In our view, this clarifies some of Norgaard's (1994) early remarks on the coevolution of technologies, culture and knowledge.

Applying these general remarks to eco-efficiency at the level of individual firms leads to some new insights. When firms start to integrate environmental concerns into their standard procedures, they do not need perfect knowledge on environmental constraints and impacts in relation to their activities. Rather they need simple heuristics that are able to increase their overall environmental performance. These simple heuristics build upon existing competences and some traditional patterns of behaviour. They will become part of firm's overall internal procedures, and are not restricted to the scope of single environmental managers. Both top managers and the individual employee require at least a basic understanding of these heuristics in order to internalise them as part of a firm's routine. Such a change certainly comes at some cost. Appropriate management tools such as the COMPASS-model developed by Kuhndt and Liedtke (1999) can lower this cost. A notion like "Factor Four – Doubling wealth, halving resource use" (Weizsäcker et al., 1997)[4] serves as normative decision rule for mid-term orientation, facilitating the search for solutions beyond optimisation of existing trajectories. As a rule-of-thumb it enables developers and strategic planning units within firms to look for new business opportunities. In doing so, it fuels capabilities for the "imagination" of new ways of combining resources that are required (Loasby, 2001, p. 18). Compared to these advantages, the various processes of the International Standardization Organization (ISO) are likely to require more information, imply higher transaction costs and do not necessarily lead to better outcomes, in particular not for small and medium-sized enterprises.

4 Factor Four is considered as one normative decision rule; other concepts such as "zero emissions", "Factor 10", the "natural step" serve similar functions but are not laid down especially here.

A cognitive perspective of eco-efficiency would thus underline a combination of normative orientation, managerial tools and striving for economic efficiency via procedures of trial and error. It will certainly lead to different mechanisms within the various firms as well as on different markets. Heuristics develop over time in different contexts. In other words, there is no "universal application of eco-efficiency" within the concept as Hukkinen (2001, p. 312) asserts, if those cognitive dimensions are applied that are obvious. The statement of Gabel and Sinclair-Desgagné (1998, p. 100) that those changes are revolutionary, disruptive and costly also seems to be misplaced. By acknowledging cognitive perspectives, eco-efficiency strategies are well advised to build upon existing competences and established patterns of behaviour, thereby avoiding establishing a new organisational code within a firm. It rather follows to permanently invest in the creation of new knowledge slightly above a level that might be regarded as optimal. Improving eco-efficiency can take a course of evolutionary, incremental and low-cost change. Chapter 5 of this paper will elaborate on that point.

4. Institutional Perspectives of Eco-Efficiency

It is interesting to note that cognitive research seems to deviate from pure individualistic approaches and begins to analyse the interplay between individual cognition and social institutions. New Institutional Economics has a strong bond on business institutions of firms and markets, analysing incomplete contracts, information exchange and enforcement procedures. The central idea is that any firm is based on the positions and actions of its individual members, i.e. it is not to be understood as a collective entity behaving like an individual actor. As long as single firms are not spurred on by inter-firm competition to invest in knowledge and skills, continuity and persistence to change are more likely than openness and flexibility. In many cases a firm's leader can pursue his or her self-interest because of less effective control (principal-agent problem). The "dynamic capabilities" model of a firm as developed by, inter alia, Langlois and Robertson (1995), Teece and Pisano (1994) provides a coherent way of identifying innovative systems of business institutions that allows for the permanent accumulation of knowledge. It explicitly takes cognitive and institutional perspectives into account. Drawing on that literature, table 1 (see below) provides a typology for institutions relevant to technological change. It becomes clear that technological change depends upon a variety of institutions, with market-based institutions partly in a central and partly in an ancillary role. An institutional mix that tailors eco-efficiency ought to take that variety into account.

Regarding eco-efficiency, institutional perspectives matter during three stages of the production chain:

- The *period* when *decisions on investments* are shaped by the legal and political framework, ideologies, and expectations about future developments, where both business and governance institutions matter;
- The *adaptation period* within a firm when best firms ought to be imitated, where business institutions matter most;
- The *period of system renewal* when incremental learning effects have come to an end and must be superseded by any new innovation where, again, both business and governance institutions matter.

Table 1: A Typology of Institutions Relevant for Technical Change

Institution	**Characteristics**	**Example**
Business institutions	Internal formal or informal institution	a) Business contracts, hierarchical order, b) Routines, business culture
Technological standards	Internal, hybrid or outer formal institution	a) Agreement among firms b) International Standardization Organisation (ISO) c) Statutory order by governments
Legal institutions for market regulation	Outer formal institution with direct impacts	Property rights, competition law, tax law, liability law, business law
Institutions for the provision of public or other common goods	Outer formal institutions with indirect impacts	Education, research, security, macroeconomic stability
Informal institutions	Informal societal institutions	Customs, ethical norms, ideologies, general expectations etc.

Source: own compilation.

Technical change can be expected to run smoothly within a stable institutional frame (exceptions resulting from "serendipity" inventions coming out of the blue indeed have to be admitted). However, as institutions change over time and are challenged to change by cognitive creation and/or competing institutions, the situation becomes more complex. Our thesis is that only incremental technical change of private goods remains within the scope of business institutions, whereas switching from one trajectory to another *and* integrating common goods strongly relies upon combining flexible business institutions such as new firms, networks or property rights with a foreseeable change in the regulatory framework allowing business institutions to adapt over time. This combination is crucial for the overall accumulation of knowledge in economic development. As Metcalfe (2001, p. 20) puts it: "It is the combination of institutions for selection and development that gives to capitalism its undoubted potential for change". Given our notions of heuristics, context-based rationality, and institutional path-dependency as outlined by David (1994) and North (1998), those processes can evolve, but take some time and are hard to predict.

Change towards a more sustainable technology development is highly intertwined with cognitive and institutional factors. Path-dependencies matter in both areas too. They do not start at any fixed time (T) caused by a singular decision, but rather during a stage of mutually interdependent decisions and frames lasting from the decision-making period to their internal adaptation. After a path has started to emerge, routine effects stabilise existing cognition and business institutions. For this reason, the overall costs of changing from one path to another become higher than without looking at cognitive and institutional dimensions. This is especially important for those eco-efficiency options which may be beneficial in standard economic terms but which require different images (e.g. small and light instead of large and massive). A technical innovation favouring a longer durability of materials or goods depends upon a complementary institutional innovation enabling business to move from production-based to service-based value. Again, normative decision rules like a Factor Four stimulate the search for innovation on a broad basis as they allow for either a combination of incremental changes within a certain trajectory (e.g. hypercar) or for changing from one trajectory to another (e.g. new energy systems). They add higher aspirations to environmental management that go beyond technological change and move the whole item up in a firm's hierarchy.

The crucial question for eco-efficiency remains as to what extent business institutions adopt to new challenges under prevailing conditions of insufficient information-processing capacities and typical market failures. How do business institutions evolve if they seek to escape the trap of reducing complexities and uncertainties down to business plans and management tools? It is exactly here that firms and markets must gain some orientation from outside. In such a situation processes of fundamental learning as analysed by Siegenthaler (1997)[5] must commence. No single rationality, neither individual nor market-based nor political, possesses enough knowledge about new institutions for an overall change and their impacts on technological change.[6] That knowledge is only created by evolutionary change itself. Here, the interaction of business institutions with the set of capabilities located in national organisations and the frameworks of law and politics arises on the research agenda. Research on eco-efficiency has to query knowledge creation and institutional progress beyond markets and firms.

5 According to Siegenthaler (1997: 756), fundamental learning involves a change in cognitive rules, a change in the rules, which govern individual information processing. It follows a situation of fundamental uncertainty characterised by a lack of confidence in such rules.

6 I do not deny the Kantian perspective of detecting imperatives from rationality. Our definition of institutions applies to a broader context and includes the social environment, i.e. the setting, enforcement characteristics, and the acceptance of rules.

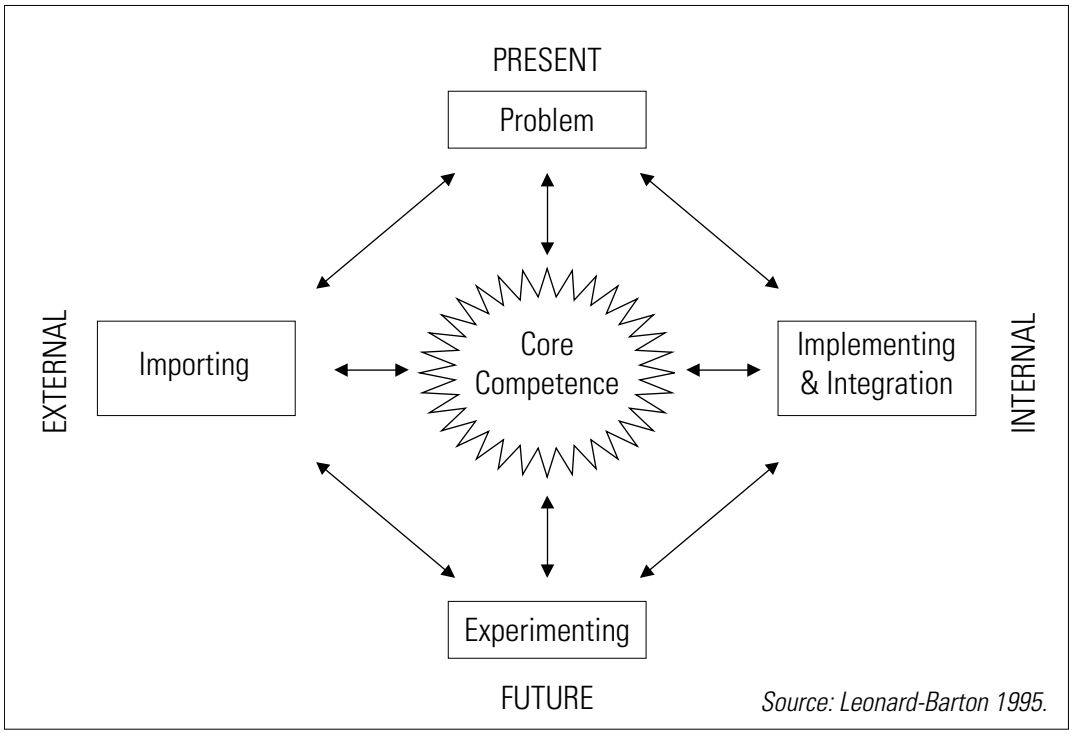
5. Knowledge Creation by Co-operation *and* Competition

Who creates knowledge for markets if not markets themselves? A simple, but straightforward answer for knowledge creation is "let's get together". Institutions create knowledge about solutions to problems via social learning processes. Such processes rely heavily on communication or, more precisely, on understanding the problem as well as on developing and testing new rules (Ostrom, 1998, pp. 12–14). Norgaard (1994, pp. 147 ff.) emphasizes in a similar vein (but in a slightly different language) the social dimension of knowing. In practical terms, it means the exchange of analysis, the development of new orientation, and it might even include tentative thoughts about business strategies. A proper mix of individuals as well as of competences and skills are crucial factors to any success. A sound and reliable leadership integrating different perspectives, working with (partly) shared mental models, dealing fairly with conflicts and aiming at common solutions is thus a critical element of learning processes. According to Ostrom (1998) and Siegenthaler (1997), new rules must be designed and weighed extremely carefully outside competitive markets within such groups of co-operative learning. New business institutions can be developed in firms, networks or niche markets. Afterwards they still have to pass their reality test. Here, markets and the actual conditions in society are back on the game. A preliminary test on niche markets provides an important intermediate step towards their full release onto national and international markets.

Can firms undertake such an exercise without hampering the specific core competence, which has developed over time? They surely can, but they have to weigh up the associated advantages and disadvantages. Whether firms take on the risk of changing their core competence will largely be related to their capabilities, i.e. to the costs of creating new capabilities and to their perception of the social and political environment. Recent theorising about a knowledge-based firm (Leonard-Barton, 1995; Grant, 1996; Granstrand, 1998; March, 1999) offers some methodological tools in analysing these processes. According to these findings, innovative firms develop new core capabilities by *permanently* striving for solutions to customers' problems, the integration of external knowledge, experimenting, and implementation of new findings. This is, indeed, a laborious task, which is illustrated by fig. 1. Such permanent striving for innovations does not coincide with the business model outlined by Gabel and Sinclair-Dasgagné (1998, pp. 108–115; 2001). Both authors view business institutions as internal constraints, whereas our approach views business institutions as capability that derives from individual cognitive abilities plus organisational features. Here, our

cognitive and institutional perspectives deviate from a traditional approach seeking to minimise transaction costs and underline the necessity to generate new knowledge by individual and organisational efforts.

Fig. 1: **Knowledge creation in firms**



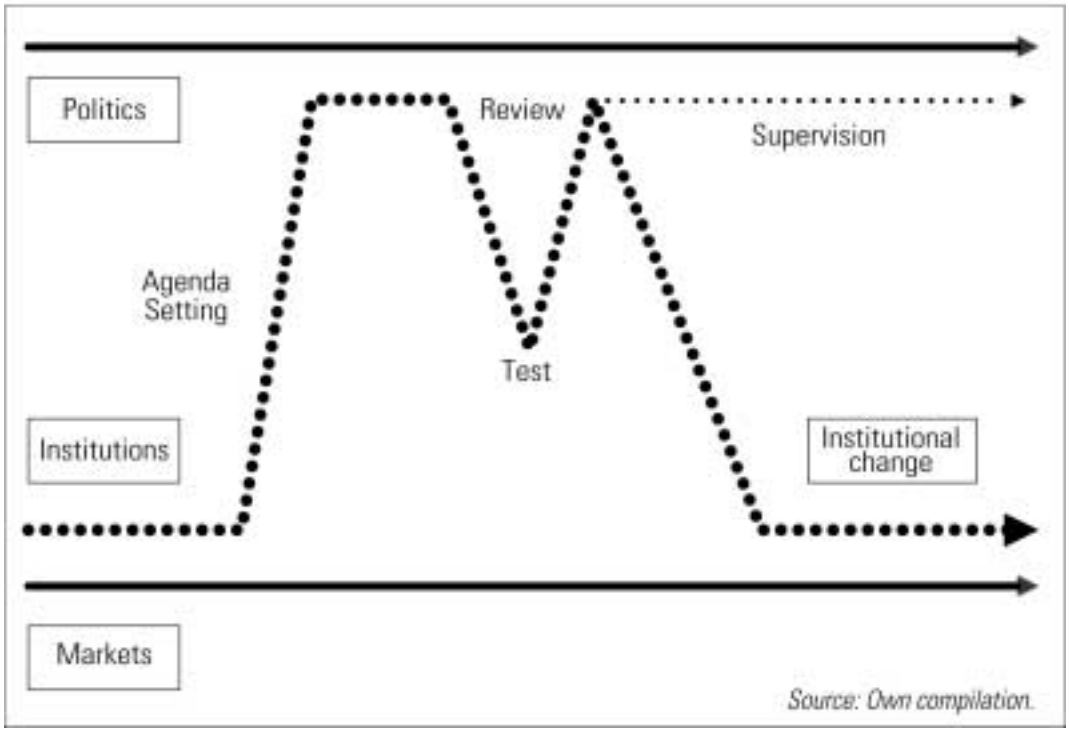
Source: Leonard-Barton 1995.

Given that firms' permanent striving for innovation will not be able to fully overcome uncertainties, market competition remains necessary as a process of both discoveries and selection. Competition leads firms towards problem solving, importing external knowledge, experimenting with new solutions and testing new hypotheses about those goods able to meet customers' demands. Decentralist market structures with small and medium-sized enterprises are crucial because a large number of independently innovative firms leads to more experimentation and, hence, towards more diversity in finding solutions. At the same time, lock-in of markets is avoided which may arise through larger companies, mergers and dense networks. Recent concepts of evolutionary competition according to Kerber and Saam (2001), Loasby (2001), and Metcalfe (2001) underline these insights. Both co-operation *and* competition remain important in any sustainable technology development and related research.

Some regulatory consequences still have to be pointed out. One relates to government. Government hardly possesses all the information necessary to steer business and society in a certain direction (e.g. to enhance eco-efficiency) by a one-time shot of framing. One comparative knowledge advantage of governments

can be seen in setting quality targets for the environment, but governments are especially weak regarding options for action at the micro level and the co-ordination thereof. At the level of decentralised decisions, markets can be expected to work better. Markets are able to produce business institutions and allocation mechanisms as soon as any minimum orientation set by targets and framing principles becomes clear. Given necessary regulatory deficits, such a framework must evolve over time and maintain some supervisory functions. Business institutions can do a good job in internalising externalities, but they surely cannot completely solve common-good problems (Ostrom, 1998, p. 17). Governments are responsible for setting the framework conditions *and* organising a process by which new knowledge on managing the commons can be gained, while markets are responsible for finding and managing solutions. Society is a critical factor in both areas, resulting from its different roles as voter, employee and consumer. Having underlined these different responsibilities, one should remember that the processes of setting targets and finding instruments are interrelated: each side has to co-operate with the other (Wegner, 1997). Such a co-operation is not meant in the sense of integration, but rather in the sense of mutual interdependence. The connection is characterised by on-and-off factors, with each activity functioning at a proper time and in a proper manner. Here, research might refer to recent analysis of transaction-cost politics (Dixit, 2000) and information economics of political processes (Stiglitz, 1998), and not to old-fashioned welfare economics.

Fig. 2: **The emergence of new institutions between markets and governments**



From a regulatory perspective the question of agenda–setting remains puzzling. Welfare economics entails a window of opportunity for any leviathan as soon as any form of market failures can be stated. Of course, standard environmental economics goes along the same vein, pointing out numerous targets, instruments, standards etc. Policy–makers are viewed to be autonomous and like-minded in their agenda setting. In contrast to these approaches, the public choice and Buchanan-perspective of the state is much more sceptical as to what extent agenda–setting is driven by bureaucrats and self-interested politicians. This debate cannot be outlined here. Relevant for this paper is the question of knowledge generation via a proper mix of institutions. Here, some elements of regulatory competition[7] during the stage of agenda–setting can be promising. If business institutions ought to evolve over time, governments will have to accept markets' abilities to bring forth appropriate solutions as well as ongoing market failures during times of transition. Some regulatory competition between governments and businesses during agenda–setting can thus be seen as a response to the question what institutional mechanisms may provide most favourable outcomes. This proposition is based upon the need for experiments as indicated in figure 1 above. In other words: self-regulation of markets may sometimes offer better results than regulation, but a permanent supervision has to be guaranteed by governments. Again, this perspective is slightly different to the view outlined by Gabel and Sinclair-Desgagné (1998, p. 113; 2001) as it tries to avoid any "stunning blow" recommended by both authors and focuses on knowledge-creating effects of economic or legal regulatory approaches. Such governance can be seen as an ongoing and powerful, but imperfect effort and not as a one-time decision of setting a frame.

Specific regulatory consequences for eco-efficiency surely depend upon domestic institutions in a country. What seems to be important is the notion of evolutionary competition driven by small and medium-sized companies that has to be supported by legal principles and authorities. In addition, normative decision rules like a Factor Four spurs competitive markets better than single technological standards to invest in new knowledge. Both elements of a regulatory framework ought to be accompanied by economic incentives such as eco-taxes because price mechanism remains to be an important communication tool. As knowledge generation is a decentralised process, legal requirements for business accounting as well as open access to this information become relevant. Any technological prospect, however optimistic it might be, thus depends upon a proper regulation for competitive markets and knowledge generation, not on technological change itself.

7 I do not enter the realm of regulatory competition here; for a balanced overview see v.d. Berg (2000) and Trachtman (2000).

6. The Case of Waste and Resource Management

The methodological advantage of cognitive and institutional perspectives can be illustrated by considering an example: waste and resource management as a possible starting point for eco-efficiency. It is illustrative because it strongly relies upon business action (and private households that are not considered here) as well as on regulatory efforts by governments. If cognitive and institutional perspectives are worth pursuing for research, our analysis should be able to provide valuable insights beyond prices and property rights. Following our perspectives, analysis starts with sound problem definition. Waste management and policies differ significantly if they are directed to disposal problems on the one hand, or if they, on the other hand, take into account the broader context of saving scarce resources, contributing to lower overall emission levels, and intervening less in natural systems. The latter, indeed, is the very essence of ecological economics *and* eco-efficiency.

In Germany, politics has undertaken an important step in formulating integrated environmental policies by reformulating existing waste law into a *Waste Avoidance, Recycling and Disposal Act* (Kreislaufwirtschafts-/Abfallgesetz) which came into force on 7 October 1996. It extends the previous waste concept by including those substances, surpluses and residues, which are neither deliberately produced nor used for any purpose. The cornerstones of the new legislation are: a) consistent application of the Polluter-Pays-Principle, b) creation of a prevention-oriented hierarchy of obligations (avoidance before thermal or material recycling), c) producers' responsibility for their products (to be reinforced by statutory order), d) extending opportunities for the privatisation of waste disposal.

At first glance, the construction of the Waste Avoidance, Recycling and Disposal Act looks like a promising way of shifting from pure disposal management to comprehensive solutions including eco-efficiency. It allows private waste businesses to be profitable and it should lead to manifold, decentralised solutions including the development of new markets between producers and users of recyclable materials. Almost six years after the Act entered into force, however, the expected gold rush in the waste avoidance industry has not yet taken place. Instead, orientation deficits are stressed, inter alia, at the international recycling trade fair 'Entsorga' in Cologne 2000. Disposal is declining, thermal recycling facilities are running, but other recycling activities, waste avoidance and resource savings are still in a premature stage. Since 1990, overall resource use has been stagnating rather than declining (see table 2).

Table 2: Trends in German Waste Production and Resource Use

	1990	1993	1997	2000
Waste Disposal	130.3	90.8	49.4	n.n.
Waste Recycling[A]	14.2	19.8	30.8	n.n.
Resource Use[B]	1 460	1 413	1 440	1 432

In Mill. Tons, figures for 1997 and 2000 on a tentative basis.
A = Includes thermal recycling, other forms of incineration and biomass recycling.
B = Includes raw material extraction in Germany used for economic purposes plus imports of raw materials.

Source: Federal Statistical Office 2001, www.destatis.de (6 March 2002).

What are the reasons for such a low adoption of waste avoidance and resource saving strategies? Along with traditional economics one may start analysis by referring to price developments. Here, competition on the markets for thermal and energetic recycling as well as the transition period until the disposal order of the "TA Siedlungsabfall" enters into force in 2005 has forced business' waste prices to stagnate or even to decline (Cantner, 2001; SRU, 2002). Beyond that analysis, information asymmetries on high quality waste management also have to be taken into account. The EU single market currently reinforces these economic distortions, as thermal recycling options outside Germany have become extremely cheap while information about their quality is poor. This coincides with widely differing environmental standards for recycling facilities in the EU. Under these conditions, emerging material recycling and waste avoidance industries maintain good arguments for postponing their investments. Waste and resource legislation does not yet lure out eco-efficiency.

These findings underline the usefulness of New Institutional Economics applied to waste issues and are well in line with our framework. Beginning here, a more particular analysis drawing on cognitive findings can depart. The question is why the emerging paradigm of eco-efficiency could not yet overcome these barriers if pursuing such a strategy is profitable now. Addressing this question, our cognitive perspective refers to the unclear scope of problem definition. Though article 1 and 4 of the German Waste Avoidance Act refer rhetorically to resource saving and waste avoidance, the whole act regulates nothing else but disposal and recycling. Firms' attention almost naturally follows these constraints. They do not yet have an incentive to assess new business markets.

Furthermore, the legal notions of resource saving and waste avoidance are vague and remain to be translated into business terms. As Ebreo and Vining (2001) point out, waste avoidance is perceived different to recycling! Any target for resource

productivity like Factor Four would offer the advantage of being scored at the level of individual businesses, but there is nothing like that in the law. Context-based behaviour at the level of individual firms adds to these deficits insofar as the economic potential of reusing or selling materials, steam, heat, the redesign of products, etc., is likely to be examined in a superficial way or even grossly ignored as long as no legal or economic incentive is advisable. Existing business institutions such as contracts, internal procedures, customer relationships, the pull-effect of recycling facilities, etc., can still be regarded tighter in their constraints than the envisaged options of waste avoidance and resource saving. Knowledge creating institutions such as accounting or reporting obligations on resource use are not yet part of German waste legislation.

On the other hand, the manifold existing initiatives to disseminate information on eco-efficiency such as the World Business Council on Sustainable Development (WBCSD), the trade fairs in Duesseldorf and Klagenfurt, etc., can be regarded experimental and don't yet outreach market niches. Against this background, it can hardly be expected for eco-efficiency to evolve from existing waste legislation, even if some principles are stated. Regulatory policies for eco-efficiency need a bias on permanent knowledge creation, and a departure from a framework for internalisation of disposal cost. According to our view, a Factor Four target (or a comparable one) for increasing eco-efficiency, reporting and accounting guidelines, agencies and other institutions for knowledge dissemination and transformation as well as a campaign driven by private initiatives would do a better job.

It is our view that such cognitive and institutional analysis offers useful insights into identifying constraints, concrete impediments to implementation, and capabilities of businesses, in particular when specific markets are analysed. It may complement traditional analysis in regard to waste disposal and recycling. Some comparative advantage can be seen as soon as emerging markets are to be analysed. Here, our methodological focus on novelty, on knowledge creation as well as on the proper institutional mix between governments, firms, and markets, seems to provide original insights beyond traditional economics.

7. Cognition and Institutions on the Research Agenda

To sum up, research perspectives on cognitive and institutional dimensions are critical to any further progress of eco-efficiency analysis. Whether or not related concepts like waste avoidance, resource management, zero emissions, and Factor Four will gain importance will depend upon the methodological acknowledgement of heuristics, context-based rationality and institutional change. Waiting for pioneering examples to trickle down into the economy would neglect both dimensions of technical change. A public provision of information on success stories would neglect the costs of knowledge generation and, thus, fall short of transforming that information into know how. Both firms and policy-makers (as well as other actors) are challenged to design appropriate institutions that allow for a maximum of adaptation flexibility at the micro level while safeguarding the evolution of a framework at the macro level. Both co-operation and competition remain important in any institutional design for a sustainable technology development. Our proposition regarding some regulatory competition between business' and governments' institutions of market regulation will lead to new governance perspectives. Accordingly, the good news is a capability of markets to internalise externalities and to provide for common goods, the bad news is its limitation in combination with limited governments' capacities. How and which types of institution make better policy and allow for adaptation flexibility at the micro level deserves further research.

Our view is thus different to the conventional assumption of minimising any institutional impact. It too departs from a division of labour that views governments autonomous from markets. We believe that our theoretical framework will allow for integrating the role of ideas, lifestyles, motivation, and consumption patterns, too, while being based upon sound assumptions of economic behaviour. In following that perspective, research can address diversity between actors and uncertainties about future developments. It will be able to analyse evolving markets as well as the impacts of regulation and other social impacts on markets. Of course, discovering the overall interaction between ecological systems, cognition, eco-efficiency, technical and institutional change will take a long time – but it will be a fascinating journey.

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